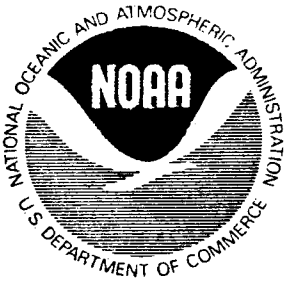

NOAA TECHNICAL MEMORANDUM

NMFS-SEFC- 124

FOOD AND GASTROINTESTINAL PARASITES OF DOLPHIN, Coryphaena hippurus, COLLECTED ALONG THE SOUTHEASTERN AND GULF COASTS OF THE UNITED STATES

Charles S. Manooch, III, Diane L. Mason, and Russell S. Nelson

November 1983

U.S. DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary
National Oceanic and Atmospheric Administration
John V. Byrne, Administrator
National Marine Fisheries Service
William G. Gordon, Assistant Administrator for Fisheries

ERRATA

1. TABLE OF CONTENTS - there is no list of figures; no list of tables. Figures are found on pages 23-26; tables on pages 27-36.
2. Page 14, paragraph 3 - blackfin tuna, Euthynnus pelamis, 26.2% (Batts 1972).
3. Page 25, Figure 3.
4. Page 26, Figure 4. Areas 1-10 are Cape Hatteras, NC, Cape Lookout, NC, South Carolina, Georgia, East Central Florida, South Florida, Northwest Florida, Mississippi Delta, Northeast Texas, and South Texas, respectively.

CONTENTS

ABSTRACT

A total of 2,632 dolphin, Coryphaena hippurus, 250 to 1,530 millimeters fork length (FL), were captured by hook and line off the southeastern United States and from the Gulf of Mexico in 1980 and 1981. Eighty-four percent (2,219) of the stomachs contained ingested materials consisting of 13,383 individual items, displacing 57,648 milliliters, and representing 248 different categories. Fishes occurred in 77.6% of the stomachs, invertebrates in 27.5%, and miscellaneous items (Sargassum, tar balls, plastics, etc.) in 50.6%. Much of the material indicated that dolphin frequently feed at the surface and ingest fishes, crustaceans, insects, plants, and inorganic items that are associated with floating Sargassum. Index of relative importance (IRI) revealed unidentified fish, balistids, crustaceans, carangids, exocoetids, teuthidids (squids), syngnathids, coryphaenids, stomatopods, and diodontids as the 10 most important foods in the diet. Sargassum, which occurred in 48.6% of the stomachs, was considered to be consumed incidental to normal foods. The diets differed with size of dolphin (8 size classes), area of collection (10 areas), and season (4 seasons). The ascaridoid nematode, Hysterothylacium pelagicum sp.n., and an unidentified digenetic trematode were found in the digestive tracts. Nematodes were far more numerous and occurred more frequently than did trematodes. Infestation rate seemed to be more associated with size of dolphin than with season or area of collection.

INTRODUCTION

Our objectives were to identify the foods and gastrointestinal parasi-parasites of dolphin, Coryphaena hippurus, collected along the southeastern and gulf coasts of the United States, and to evaluate differences in the diets and parastic infestations associated with size of dolphin, area of collection, and season. We anticipate that the large data base (number of fish, geographic coverage, and time frame) analyzed will be used by Regional Fishery Management Councils to assist them in preparing management plans for pelagic fishes as provided for under the Magnuson Fishery Conservation and Management Act of 1976.

The dolphin is a large pelagic species (up to 39.5 kg) that inhabits tropical and subtropical waters of the world. In the western Atlantic, dolphin are distributed from Canada to Brazil, including the Caribbean and Gulf of Mexico. Because they are generally restricted by the 20° isotherm (Gibbs and Collette 1959), they are rarely found north of North Carolina.

The species is very important to recreational fishermen in the region, particularly those with large private boats and those that charter boats to reach the offshore fishing grounds. A survey of United States marine recreational fisheries in 1979 estimated that 2,762,000 dolphin were landed along the southeastern coast and 41,000 along the gulf. (Fisheries of the United States, 1981, 1982); however, we believe that these estimates are high. Based upon data from geographically smaller surveys, we do know that dolphin are important to recreational charter boat fisheries, particularly those in North Carolina, the east coast of Florida, and the Florida Keys. Rose and Hassler (1969) estimated that the North Carolina charter boat catch in 1962 was 68,000 fish, and Manooch, Abbas and Ross (1981) reported that the catch in 1978 was 52,480 fish (6.2 fish/trip) weighing 124,847 kg. Browder et al. (1981) found that Key West, Fl charter boat anglers spent 39% and 43% of their efforts fishing for dolphin in the spring and summer, respectively.

METHODS

From April 1980 to October 1981, 2,632 dolphin between 250 and 1,530 millimeters fork length (FL) were sampled from hook and line recreational catches from North Carolina to Texas. The sampling area included six major locations along the southeastern United States: Cape Hatteras, NC; Cape Lookout, NC; SC; GA; east central Florida; and south Florida; and four areas in the Gulf of Mexico: northwest Florida; Mississippi delta (Mississippi-Louisiana); northeast Texas; and south Texas (Figure 1). Samplers at all locations apportioned their efforts to coincide with local charter boat and head boat fishing activities, primarily April through November. They met the boats as a day's catch was being unloaded and asked individual fishermen to let them weigh, measure, and eviscerate their catch. Fish were measured to the nearest millimeter and weighed to the nearest tenth of a kilogram. Stomachs and gonads were placed in labeled cloth bags or cheesecloth and preserved in 10% formalin.

In the laboratory, stomach contents were identified to the lowest taxon possible and were enumerated, thus providing the relative number of each food type in the stomachs. Frequency of occurrence of materials was determined by counting every stomach that contained at least one specimen or part of a specific item (taxon). Empty stomachs were excluded. The volume of each taxon was obtained by water displacement.

Larval and juvenile fish from the stomachs were identified after they had been cleared and stained, following the methods discussed by Dingerkus and Uhler (1977) and Taylor and Van Dyke[1]. Crustaceans were identified with the assistance of Steven G. Morgan, University of Maryland, College Park.

[1] Taylor, W. R., and G. C. Van Dyke. 1978. Unpublished manuscript. Staining and clearing small vertebrates for bone and cartilage study. Smithsonian Institution, Washington, DC 20560. 19 pp.

Parasites, primarily ascaridoid nematodes, were separated from food items, counted, identified, and preserved. A stomach that contained only parasites was considered empty for food study purposes.

All data were analyzed as percent frequency of occurrence, percent of total number, and percent of food volume. Once frequencies, volumes, and numbers of the various foods were obtained, the importance of each major food group was judged on the basis of its Index of Relative Importance (IRI) (Pinkas, Oliphant and Iverson 1971). The index was calculated as

$$IRI = (N + V) F, \text{ where}$$

N = numerical percentage of a food, V = its volumetric percentage, and F = its percentage frequency of occurrence.

Differences in the diet were evaluated by dolphin size (<300 mm FL, ≥300-<500, ≥500-<700, ≥700-<900, ≥900-<1,100, ≥1,100-<1,300, ≥1,300-<1,500, and ≥1,500 mm), area of collection, and season (spring: March, April, May; summer: June, July, August; fall: September, October, November; and winter: December, January, February).

RESULTS

Synopsis of Food Types

Fish

Fish, the dominant food, occurred in 77.6% of the stomachs containing food (Table 1). Piscivorous habits of dolphin were further substantiated by numbers (78.8% or 10,549 items) and volume (89.8% or 51,785 ml). In total, 34 families representing 55 species of fish were identified. While some fish were adults, or large, such as scombrids, exocoetids, and coryphaenids, many were juveniles. In fact, besides those identified to family or genus, unidentified juvenile fishes alone occurred in 24% of the stomachs and represented 14% of the number of all items.

The most frequently eaten fish were balistids, which occurred in 31.5% of the dolphin stomachs, and comprised 23.5% of the number, and 13% of the food volume. Seven species were recognizable: Aluterus schoepfi, A. scriptus, Balistes capriscus, Cantherhines pullus, Canthidermis sufflamen, Melichthys niger, and Monacanthus hispidus. These were typically juveniles and were from stomachs that contained Sargassum or other floating materials.

The second most important group of fishes, and the most diverse, were carangids, found in 10% of the dolphin stomachs. Fourteen species were identified, including both medium and small-sized individuals of the genera: Caranx, Chloroscombrus, Decapterus, Hemicaranx, Selar, Selene, Seriola, Trachinotus, and Uraspis.

Two other families, Exocoetidae and Syngnathidae, contributed significantly to the diet. Flyingfish, flying halfbeak, and ballyhoo occurred in 6% of the stomachs and contributed 13.5% of the volume. Most were adults and were presumably captured after brief chases in surface waters of the open ocean. Pipefishes, primarily seahorses, Hippocampus sp., were found in 5.4% of the stomachs. But unlike the flyingfish, they always occurred in stomachs containing Sargassum, which suggests that they were picked from concentrations of the floating plant.

In addition to feeding on balistids, dolphin fed upon other fishes that are usually considered demersal as adults but that are pelagic as larvae or juveniles. Representative families were Holocentridae, Serranidae, Priacanthidae, Lutjanidae, Sparidae, Sciaenidae, Pomacentridae, Mullidae, Chaetodontidae, Acanthuridae, and Bothidae. As with the filefish and triggerfish, these were typically larvae or juveniles that have a pelagic early life phase. Obviously not juveniles, and considered inhabitants of the bottom, were a large bank sea bass, Centropristis ocyurus, a dog snapper, Lutjanus jocu, five pinfish, Lagodon rhomboides, a seatrout, Cynoscion sp., and four unidentified flounders. The pinfish may have been bait.

Invertebrates

Invertebrates, almost entirely mollusks and crustaceans, were of secondary importance, occurring in only 27.5% of the stomachs (Table 1). Although relatively large numbers were encountered (2,834, 21.2%), the volume was only 5.9% of the total, thus exemplifying their small average volume (about 1.2 ml).

Squids (Teuthidida), not identified to genus or species, but probably Loligo spp., were the principal mollusks encountered, and occurred in 12.7% of the stomachs but contributed only 2.4% and 4.1% of the number and volume, respectively. Paper nautilus, Argonauta argo (Octopodida), were also eaten by dolphin and always occurred in stomachs containing pelagic larval crustaceans.

In total, crustaceans occurred in 16.8% of the stomachs and represented 18.5% of the number, and 1.6% of the volume (Table 1). The mean volumetric displacement was only 0.37 ml. The smallest organisms eaten were immature crustaceans. Crustaceans also were diverse; the most important by frequency of occurrence were portunids (5.1%), dromiids (3.6%), and stomatopods (2.8%).

A relatively small, but ecologically significant portion of the diet comprised insects, typically terrestrial and probably transported by winds offshore, where they became concentrated on rafts of floating Sargassum. Four orders were found: Odonata, Hemiptera, Coleoptera, and Hymenoptera (Table 1).

Miscellaneous

Some material not regarded as food and probably consumed incidentally to fishes and invertebrates, included plant material such as Sargassum, Thalassia testudinum, Zostera marina, Spartina patens, and parts of mangroves, and objects discarded from seagoing craft. Examples of the latter were plastic wrappers, small light bulbs, cigarette wrappers, balls of tar, and tops of plastic containers (Table 1). Sargassum, by far the dominant non-food item, occurred in 48.6% of all stomachs and constituted 3.2% of the volume.

Variations in Food Habits

By Size

The food habits of dolphin changed as the fish grew larger. Fish was the dominant food category for all sizes, but occurred more frequently (100%) in larger dolphin than they did in smaller individuals (84%). Conversely, invertebrates were generally more important in the diet of smaller fish. Selected frequency of occurrence data by fish size are presented graphically (Figure 2). Tabular data by fish size classes are available at the Southeast Fisheries Center's, Beaufort Laboratory.

The smallest dolphin, whose stomachs were examined, were 13 individuals <300 mm FL. Ranked by IRI values, the seven most important foods were unidentifiable fish, squid, Balistidae, Crustacea, Carangidae, Stomatopoda (larvae), and Amphipoda. Sargassum, indicative of surface feeding, was found in 23% of the stomachs.

For the 987 fish of the next category, ≥ 300 to 500 mm FL, invertebrates were also important in the diet. The 10 most important groups were unidentified fish, Crustacea, Balistidae, Carangidae, squid, Stomatopoda (larvae), Dromiidae (megalopa), Penaeidea, Portunidae, and Caridea (Latreutes fucorum and Leander tenuicornis). Sargassum occurred in 49% of the stomachs.

The third size group, ≥ 500 to <700 mm, contained the second largest number of fish examined (N=686). The 10 most significant contributors to the diet were unidentifiable fish, Balistidae, Crustacea, Carangidae, Teuthidida, Exocoetidae, Stomatopoda, Syngnathidae, Diodontidae, and Portunidae. Sargassum was found in over half (55%) of the stomachs.

The fourth category, ≥ 700 to <900 mm FL (N=192), contained noticeably larger fish such as scombrids and exocoetids. The 10 highest IRI values were: unidentifiable fish, Balistidae, Exocoetidae, Syngnathidae, Crustacea, Teuthidida, Carangidae, Scombridae, Portunidae, and Diodontidae. Sargassum occurred in 43.8% of the stomachs.

For fish ≥900 to <1,100 mm FL (N=189), small dolphin ranked fourth in the list of food categories. Other items were Balistidae, unidentifiable fish, Exocoetidae, Crustacea, Diodontidae, Syngnathidae, Portunidae, Carangidae, and Teuthidida. Sargassum was encountered in 43% of the stomachs.

Dolphin larger than 1,100 mm FL were not common (N=71). Sixty-eight were 1,100-1,300; two, 1,300-1,500; and one >1,500. Fish were the dominant foods of these larger individuals, and only fish were found in the stomachs of the three largest dolphin. Sargassum was extracted from 38.2, 50.0, and 0.0% of the three size classes, respectively. Rose and Hassler (1974) noted that large dolphin, usually males, fed less frequently in the vicinity of weed-lines.

By Season

Most dolphin (76%) were collected during the summer, when charter boat anglers most actively pursue the species. Selected food frequency of occurrence data by season are presented graphically (Figure 3). Tabular data by season of collection is available at the Beaufort Laboratory.

Two hundred and eighty-seven dolphin were collected in spring. Fish occurred in 77%, invertebrates in 32.7%, and miscellaneous items in 58.9% of the stomachs. Ranked by IRI values, the 10 most important food categories in the diet were unidentified fish, Syngnathidae, squid, crustaceans, Balistidae, Exocoetidae, Portunidae, Diodontidae, Clupeidae, and Carangidae. Within fish familial groupings, Hippocampus sp. (seahorse) and Monacanthus sp. (filefish)

were the most frequently encountered prey.

The 1,660 stomachs collected during the summer contained the highest diversity of contents; fish occurred in 88%, invertebrates in 26.1%, miscellaneous in 53.2%. The most important foods, ranked by IRI, were unidentified fish, Balistidae, Crustacea, Carangidae, Exocoetidae, squid, Coryphaenidae, Syngnathidae, Diodontidae, and Stomatopoda.

In the 207 stomachs collected during fall, fish occurred in 86.5%, invertebrates in 44%, and miscellaneous items in 31.9%. The most diverse groups were carangids and balistids. Invertebrates were encountered more frequently than during spring or summer. Five of the top 10 food groups were invertebrates. By IRI ranking the most important were unidentified fish, Crustacea, Carangidae, Balistidae, Stomatopoda, Dromiidae, squid, Trichiuridae, Penaeidae, and Exocoetidae.

Only 34 fish were collected in winter. Fishes were dominant and occurred in 97% of the stomachs. Eight of the top 10 food groups were fish. Invertebrates were found in only 20.6%, and miscellaneous contents in 41.2%. By IRI ranking Exocoetidae, unidentified fish, Syngnathidae, Mugilidae, squid, Carangidae, Sparidae, Crustacea, Scombridae, and Belonidae were most important to the diet.

By Area

Within two major geographic areas - southeastern United States (North Carolina through the Florida Keys) and the Gulf of Mexico (west coast of Florida through Texas) - we sampled at 10 locations (Figure 1). Results for each location are discussed below and selected foods are presented graphically (Figure 4). Tabular data by area of collection are available at the Beaufort Laboratory.

Four hundred and forty stomachs with food were collected off Cape Hatteras, NC. Fish were found in 90.7%, invertebrates in 35.9%, and miscellaneous items in 57.3% (Sargassum, 52%). Most were those that typically form, or are associated with, the offshore Sargassum community. Principal foods were Balistidae, unidentfied fish, Crustacea, Syngnathidae, Stomatopoda, Carangidae, squid, Coryphaenidae, Diodontidae, and Portunidae. By genus, the most numerous fishes were Hippocampus (seahorse), Monacanthus (filefish) and Aluterus (filefish). Crab larvae and squids were the most numerous invertebrates.

Stomachs contents of 170 dolphin captured off Cape Lookout, NC were very similar to those of fish from Cape Hatteras. In fact, with the exceptions of Penaeidae, which replaced Diodontidae, and fewer stomatopods, 8 of the 10 major contributors were the same as those for Cape Hatteras fish. Ranked, the groups were unidentified fish, Balistidae, squid, Exocoetidae, Crustacea, Coryphaenidae, Carangidae, Syngnathidae, Penaeidae, and Portunidae. Overall, fish occurred in 95.9% of the dolphin stomachs, invertebrates in 31.8%, and miscellaneous, 54.1% (Sargassum, 53.5%). The appearance of a mangrove seed in one stomach indicates a southern connection, either by transport of the seed by Gulf Stream currents, or migration of the fish from Florida waters to North Carolina.

The 158 fish collected off South Carolina provided a parallel dietary picture to that of dolphin sampled off North Carolina, although carid shrimps were among the principal foods. The major items were unidentified fish, Exocoetidae, Balistidae, Crustacea, Stomatopoda, squid, Portunidae, Syngnathidae, Carangidae, and Caridea (especially, Leander tenuicornis). Fish appeared in 89.9% of the stomachs, invertebrates in 31.6%, and miscellaneous items in 44.9% (Sargassum, 42.4%). Seahorses, filefish, chub mackerel, and flyingfish were the most numerous prey fishes, whereas portunid crabs, carid shrimps, and squid were the most abundant invertebrates.

Only 35 and 28 dolphin were collected off Georgia and the east central coast of Florida, respectively. Because of the small samples, the lists of foods were relatively brief. Fishes, invertebrates, and miscellaneous items occurred in 91.4%, 28.6%, and 62.9% of the stomachs collected off Georgia, compared with 100%, 17.9%, and 21.4% for those from Florida. Exocoetidae, Crustacea, Diodontidae, Portunus sp., Balistidae, Carangidae, squid, Sicyonia sp., Gastropoda, and unidentified carid ranked as the 10 most important contributors to the diet of fish collected off Georgia, and unidentified fish, Balistidae, squid, Exocoetidae, Clupeidae, Tetradontidae, and Portunus sayi rank highest for Florida fish.

Eight hundred and sixty-four dolphin were examined from the South Florida area, more than from any other location. Their diet, especially the fishes eaten, was very diverse, resulting, in part, from the large number of larval and juvenile reef fishes. Eighty-six percent of the stomachs contained fish represented by 27 families and many species. Invertebrates were much less abundant, 19.7% by frequency of occurrence. Crustaceans were encountered in only 6.9% of the samples and contributed little to the number and volume of the overall food intake. Miscellaneous items, represented by Sargassum (55.8%), several seagrasses, mangrove root and leaves, and pieces of plastic wrapping material, were found in 57.9% of the stomachs. The 10 most important groups of foods were unidentified fish, Balistidae, Carangidae, Exocoetidae, squid, Syngnathidae, Coryphaenidae, Crustacea, Diodontidae, and Portunidae. By number, Hippocampus, Aluterus, Cantherhines, Monacanthus, and Hemiramphus were the most abundant genera of fishes eaten.

Five hundred and seven dolphin were collected from the Gulf of Mexico. Most (364) were sampled from the northwest Florida area. Fish were found in

91.7%, invertebrates in 26.2%, and miscellaneous items in 44.3% of the stomachs. Compared with previously discussed areas, Sargassum was less frequently encountered (39.4%). By number, Diodon, Decapterus, and Monacanthus sp. were the most important genera of fish, and stomatopods, squid, and dromiid crab megalopa were the most abundant invertebrates. The 10 highest ranked food categories were unidentified fish, Balistidae, Carangidae, Crustacea, Diodontidae, Coryphaenidae, squid, Dromiidae, Stomatopoda, and Clupeidae.

Only 18 dolphin were collected off Louisiana and Mississippi. Fish occurred in all specimens, invertebrates in 27.8%, and miscellanea in only 16.7%. Stomatopod larvae, portunid crabs, and Atlantic bumper, Chloroscombrus chrysurus, were the most numerous items identified. Index of relative importance ranking revealed unidentified fish, Crustacea, Carangidae, Stomatopoda, Portunidae, Coryphaenidae, Sciaenidae, squid, Engraulidae, and Ostraciidae as the most important groups.

Eighteen fish were also collected off the northeast coast of Texas, but unlike fish from any other sampling site, these dolphin had a slighty higher frequency of occurrence of invertebrates (66.7%) than fish (61.1%). The major contributors to the diet were Crustacea, squid, Carangidae, unidentified fish, Stomatopoda, Balistidae, Stomateidae, Portunidae, Latreutes fucorum, and Diodontidae. Thus, 5 of the top 10 categories were invertebrates.

One hundred and seven stomachs were obtained from south Texas and provided the basis for a more detailed analysis of dolphin dietary habits in the western Gulf. Fish, invertebrates, and miscellaneous items occurred in 74.8%, 67.3%, and 31.8% of the south Texas fish, respectively. As with the northwest Texas fish, invertebrates made a major contribution to the diet. The 10 highest ranked IRI categories were unidentified fish, Crustacea, Dromiidae, Balistidae, Penaeidea, Trichiuridae, squid, Carangidae, Coryphaenidae, and Stomatopoda. Dromiid crab megalopa were the most numerous items consumed.

Parasites

Stomachs of 2,630 dolphin were examined for parasites, but only the ascaridoid nematode Hysterothylacium pelagicum sp. n. (Deardorff and Overstreet 1982), and an unidentified digenetic trematode were found. Nematodes were far more numerous and occurred more frequently than did trematodes; 4.5 to 5.0% of the dolphin contained the former, whereas only 0.65 to 0.72% of the fish were infested with trematodes (Tables 2-4).

By Size

Parasitic infestation generally increased with fish size (Table 2). For instance, the frequency of occurrence of nematodes was 0.0% for dolphin <300 mm FL; 15.3% for those $\geq$ 700 - <900; and 22.7% for fish $\geq$1,100 - <1,300 mm. Small sample sizes probably biased results for the few dolphin >1,300 mm. The mean number of nematodes per parasitized fish also increased with fish size. Dolphin <300 mm had 0 compared with approximately 15 for those 1,100 to 1,300 mm (for all size classes $\bar{X}$ = 11). Occurrence of trematodes and number of worms per infested fish revealed similar trends.

By Season

There appeared to be no significant correlation between parasitic infestation and season (Table 3), although the incidence of infestation was slightly greater in spring (6.4% of the dolphin), and lower in fall (1.2%) (Table 3).

By Area

Generally, dolphin sampled along the southeastern United States were more heavily parasitized with nematodes than were those from the Gulf of Mexico (Table 4). The obvious exception were fish collected from the Mississippi delta, although only 21 dolphin were analyzed from that location.

DISCUSSION

Dolphin may be described as fast, aggressive predators that pursue and capture such actively swimming fish as flyingfish, mackerels, and juvenile dolphin, and yet at times seem content to simply graze on small shrimps, crabs, and insects that float on the surface of the water. Thus, the diet is very diverse and includes numerous fishes and invertebrates, many of which comprise the Sargassum community. Indeed, most of the fishes closely associated with Sargassum as listed by Dooley (1972) for the Florida Current, and by Bortone et al. (1977) for the eastern Gulf of Mexico were identified in stomachs we examined. And many of the invertebrates such as penaeid and carid shrimps, and dromiid and portunid crabs, inhabit weed-lines as adults, or passively concentrate there as juveniles (S. Morgan, pers. commun., University of Maryland, College Park).

One of the major contributions of this paper is that we have documented the importance of the Sargassum community to dolphin, and therefore to anglers that fish for the species. Traditionally, fishermen seek weed-lines to land dolphin and other pelagic fishes. Seasonal angling success has been associated with the distribution of Sargassum along the southeastern United States. For instance, Rose and Hassler (1974) suggested that diminished landings of dolphin

off North Carolina were probably caused by the lack of tide-lines (usually identified by floating rows of Sargassum) rather than by overfishing in previous years as some believed. Perhaps monthly (seasonal) forecasts could be made on the occurrence and abundance of Sargassum, thereby providing a service to fishermen. We found that almost half (48.6%) of the stomachs contained the plant. Because plant material is more resistant to digestion than animal material, and because much of the fishing effort is directed towards weed-lines, data presented may be biased in favor of fishes with Sargassum. However, this still seems to be an impressive rate of occurrence. Rose and Hassler (1974) found Sargassum in 28% of the 396 fish from North Carolina, and other researchers refer to the importance of large floating objects in attracting the species (Palko et al. 1982).

There was definitely a seasonal trend in the occurrence of Sargassum in dolphin stomachs: spring, 55.1%; summer, 50.9%; fall, 29.5%; and winter, 41.2%. Dooley's (1972) data revealed the highest biomass of the algae was obtained from the Florida Current in May-June 1966, months that correspond with the end of our spring season and the start of the summer.

Other pelagic species also have been found to contain Sargassum in their digestive tracts, although at lower frequencies: yellowfin tuna, Thunnus albacares, 26.5% (Manooch and Mason, 1983); blackfin tuna, T. atlanticus, 12.4% (Manooch and Mason, 1983); and skipjack tuna, Euthynnus pelamis (Batts 1972). The relative contribution of the Sargassum community to the diet may be indicative of physiological constraints on the foraging behavior of these pelagic predators. The pursuit and capture of free-swimming prey in the open ocean is energetically expensive, while grazing on relatively sessile animals associated with Sargassum can be accomplished without great energy expenditure. The tunas consume a greater proportion of pelagic, adult fishes and take less prey from the

Sargassum community than do the dolphin. Although both tunas and dolphin are capable of high speed pursuit, tunas have highly vascularized locomotion muscles enabling sustained aerobic metabolism. Dolphin, with a much smaller proportion of red muscle, must rely primarily on anaerobic metabolic pathways (mainly glycolosis), and therefore are limited to short bursts of acceleration (Nursall 1956; Webb 1975). Thus the energetic strategy for dolphin seems to be to forage primarily on smaller prey from the Sargassum community, but also to capture larger prey with short bursts of high speed pursuit if the opportunity arises.

Finding miscellaneous items such as tar balls and plastics in the digestive tracts of dolphin is another important result of our study. Since these materials were obviously discarded by man at sea, dolphin could serve as indicators of environmental conditions of offshore surface waters, particularly those threatened by oil spills and ocean dumping. The indications, however, may be vague, since dolphin are highly migratory and the ingested materials could remain virtually unaltered in the stomachs for an usually long period of time. Even with these limitations, dolphin could contribute to our knowledge of surface water quality and the biological concentrations of certain solid and liquid wastes.

The foods eaten by dolphin are so diverse that it is difficult to conduct a meaningful comparison of our data with those of other researchers. The larger the sample size, the more diverse the diet, and most of the previous studies have involved very few fish. Although increasing sample size to obtain a better, statistically reliable picture of food diversity is not new, relatively few samples, for many predators, will yield most of the foods eaten for a given geographical area, season, and predator size (Hoffman 1978; Grossman et al. 1980). But it is not necessarily true for dolphin, a highly migratory fish that

feeds on virtually any species of consumable-size fish or invertebrate that is available. Our large data base does little to clear the issue. The 440 stomachs we collected off Cape Hatteras would seem comparable to the 396 stomachs collected by Rose and Hassler (1974) from approximately the same area. But they found by percent of food volume, Exocoetidae (26%), Scombridae (22%), Carangidae (12%), Balistidae (9%), Coryphaenidae (5%), Portunidae (4%), and squid (3.5%) to be the major groups of foods eaten. We found percent volumes for the same foods to be: 4.3, 5.4, 4.4, 18.6, 19.4, 1.0, and 3.7%, respectively. The low similarity between the two data sets may be attributable to variation in prey availability. Palko et al. (1982) synopsis on biological data on Coryphaena hippurus, and C. equiselis offers little substantive information on the overall food habits of dolphin stocks along the southeastern United States and in the Gulf of Mexico.

Since dolphin feed as generalists on a wide variety of prey, significant differences in diets attributable to different faunal assemblages can be expected if areas and seasons are compared. The change in feeding habits with increased predator size is noteworthy, particularly if the fish were collected from the same area at about the same time. For all areas and seasons combined, the general trend was an increased dependency on fishes rather than invertebrates as the dolphin attained larger sizes. The trend might have been more pronounced had we analyzed fish of varying sizes that were caught simultaneously. Shcherbachev (1973) found a similar fish size-foods pattern for 57 common dolphin captured in the Atlantic, Indian, and Pacific Oceans. Individuals 15 to 67 mm SL (standard length) contained crustaceans, Hemiramphidae, Exocoetidae, and Coryphaenidae at frequency of occurrence rates of 96%, 9%, 4%, and 9%; dolphin 130 to 174 mm SL contained cephalopods and fishes at 60% and 100% frequencies; and fish 285 to 1,100 mm SL ingested cephalopods and fish at 23% and 90% frequencies.

The cannibalistic nature of dolphin was indicated by the presence of young-of-year in 36 of the 2,219 (1.6%) stomachs. Rose and Hassler (1974) identified 15 young dolphin (3.8%) in fish collected off North Carolina. Even very small dolphin are cannibalistic. Shcherbachev (1973) found that 9% of the fish 15 to 77 mm SL had ingested coryphaenids.

Palko et al. (1982) listed many parasites including monogenetic and digenetic trematodes, nematodes, isopods, cestodes, acanthocephalans, copepods, and others as infesting coryphaenids. The majority parasitize the gills, buccal cavity, stomach, and intestines. Since parasitism was a secondary study objective, our data reflect only macroscopic observations of the parasitic endofauna of the stomachs.

We found two types of worms: nematodes, Hysterothylacium pelagicum sp. n. and unidentified digenetic trematodes, possibly, Hirudinella sp. Hysterothylacium pelagicum has recently been described by Deardorff and Overstreet (1982) in common dolphin collected off Hawaii, in the Gulf of Panama, in the Gulf of Mexico off Alabama, and off South Carolina. These researchers noted that the frequency of parasitism by the nematodes was 57.6% (19 of 33 fish) from Hawaii, and that intensity ranged from 1 to 35 worms ($\bar{X}$ = 10). Our data revealed a much lower infestation rate, 5%, and numbers of parasites ranging from 1 to 100 ($\bar{X}$ = 11). Rose (1966) identified three types of parasites in common dolphin captured off North Carolina: the isopod Livoneca ovalis; the nematode Contracaecum (synonomized with Hysterothylacium Deardorff and Overstreet 1982), which Rose described as extremely abundant; and an unidentified acanthocephalan that was encysted in the stomach wall of one dolphin.

We confirmed Burnett-Herkes (1966; 1974) findings that incidence and intensity of infestation increased with fish size. This seems plausible since

the parasites would concentrate within the host through time. We found infestation trends to be less pronounced when we analyzed data by season and area of collection. However, small sample sizes, particularly for some areas, and the compounding effect of fish size would obviously make these comparisons much more difficult.

In summary the major contributions of this study are:

1. The overall results present the world's largest data base in terms of number of dolphin analyzed, sizes of fish, geographical coverage, and time. No such study has been conducted on the foods and parasites of this cosmopolitan species anywhere in the world, and probably would not be duplicated in scope.
2. The close association (= dependency) of dolphin with fish and invertebrates that form the Sargassum community is unmistakable. We propose that periodic forecasts of the location and abundance of tide-lines would be directly beneficial to oceanic pelagic fisheries operating in the region.
3. Since the dolphin does ingest a wide range of non-food materials, we propose it as an indicator species for offshore surface water quality, particularly in areas threatened by oil spills or subject to ocean dumping.
4. The species is demonstrated to be a voracious predator that pursues and captures fast-swimming fishes such as exocoetids, scombrids, carangids, and other coryphaenids. It also evidently spends much of its time nibbling (picking) small shrimps, crabs, insects, and fishes that are found on or near the surface of the water. Further, a feeding strategy that relies on relatively sessile animals (such as those associated with Sargassum) is probably physiologically advantageous to the dolphin since, unlike the tunas, it does not possess adaptations for long-term, open ocean pursuit of prey.

5. The parasites encountered were typically those that occur as juveniles and adults solely in the digestive tract. Thus, even heavy infestations of these parasites would not reduce the aesthetic or commercial acceptability of dolphin.

LITERATURE CITED

Batts, B. S. 1972. Food habits of the skipjack tuna, Katsuwonus pelamis, in North Carolina waters. Chesapeake Sci. 13:193-200.

Bortone, S. A., P. A. Hastins, and S. B. Collard. 1977. The pelagic-Sargassum ichthyofauna of the eastern Gulf of Mexico. Northeast Gulf Sci. 1:60-67.

Browder, J. A., J. C. Davis, and E. Sullivan. 1981. Paying-passenger recreational fisheries of the Florida Gulf coast and Keys. U.S. Natl. Mar. Fish. Serv., Mar. Fish. Rev. 43(8):12-20.

Burnett-Herkes, J. N., Jr. 1966. An ecological study of the parasite infesting the gills and buccal cavity of the dolphin-fish, Coryphaena hippurus Linnaeus caught in the Miami area. M.S. Thesis, Univ. Miami, Miami, Fla., 162 pp.

Burnett-Herkes, J. N., Jr. 1974. Parasites of the gills and buccal cavity of the dolphin, Coryphaena hippurus, from the Straits of Florida. Trans. Am. Fish. Soc. 103:101-106.

Deardorff, T. L., and R. M. Overstreet. 1982. Hysterothylacium pelagicum sp. m. and H. cornutum (Stossich, 1904) (Nematoda: Anisakidae) from marine fishes. Proc. Helminthol. Soc. Wash. 49:246-251.

Dingerkus, G., and C. D. Uhler. 1977. Enzyme clearing of alcian blue stained whole small vertebrates for demonstration of cartilage. Stain Technol. 52:229-232.

Dooley, J. K. 1972. Fishes associated with the pelagic Sargassum complex, with discussion of the Sargassum community. Contrib. Mar. Sci. 16:1-32.

Fisheries of the United States, 1981. 1982. U.S. Natl. Mar. Fish. Serv., Curr. Fish. Stat. 8200, 131 pp.

Gibbs, R. H., Jr., and B. B. Collette. 1959. On the identification, distribution, and biology of the dolphins, Coryphaena hippurus and C. equiselis. Bull. Mar. Sci. Gulf Caribb. 9:117-152.

Grossman, G. D., R. Coffin, and P. B. Moyle. 1980. Feeding ecology of the bay goby (Pisces: Gobiidae). Effects of behavioural, ontogenetic, and temporal variation on diet. J. Exp. Mar. Biol. Ecol. 44:47-59.

Hoffman, M. 1979. The use of Pielou's method to determine sample size in food studies. In S. J. Lipovsky and C. A. Simenstad (editors), Fish food habits studies, p. 56-61. Wash. Sea Grant Publ. WSG-WO 79-1.

Manooch, C. S., III, L. E. Abbas, and J. L. Ross. 1981. A biological and economic analysis of the North Carolina charter boat fishery. U.S. Natl. Mar. Fish. Serv., Mar. Fish. Rev. 43(8):1-11.

Manooch, C. S., III, and D. L. Mason. 1983. Comparative food studies of yellowfin tuna, Thunnus albacares, and blackfin tuna, Thunnus atlanticus, (Pisces: Scombridae) from the southeastern and Gulf coasts of the United States. (Abstract and Summary: in English, Polish and Russian). Acta Ichthyol. Piscatoria 13:

Nursal, J. R. 1956. The lateral musculature and the swimming of fish. Proc. Zool. Soc. Lond. 126(1):127-143.

Palko, B. J., G. L. Beardsley, and W. J. Richards. 1982. Synopsis of the biological data on dolphin-fishes, Coryphaena hippurus Linnaeus and Coryphaena equiselis Linnaeus. U.S. Natl. Mar. Fish. Serv., Circ. 443; and, FAO Fish. Synop. 130, 28 pp.

Pinkas, L., M. S. Oliphant, and I. L. K. Iverson. 1971. Food habits of albacore, bluefin tuna, and bonito in California water. Calif. Dep. Fish Game Fish Bull. 152:1-105.

Rose, C. D. 1966. The biology and catch distribution of the dolphin, Coryphaena hippurus (Linnaeus), in North Carolina waters. Ph.D. thesis, N.C. State Univ., Raleigh, 153 pp.

Rose, C. D., and W. W. Hassler. 1969. Application of survey techniques to the dolphin, Coryphaena hippurus, fishery of North Carolina. Trans Am. Fish. Soc. 98:94-103.

Rose, C. D., and W. W. Hassler. 1974. Food habits and sex ratios of dolphin Coryphaena hippurus, captured in the western Atlantic Ocean off Hatteras, North Carolina. Trans. Am. Fish. Soc. 103:182-190.

Shcherbachev, Yu N. 1973. The biology and distribution of the dolphins (Pisces, Coryphaenidae). Am. Fish. Soc. J. Ichthyol. (Engl. transl. Vopr. Ikhtiol.) 13:182-191.

Webb, P. W. 1975. Hydrodynamics and energetics of fish propulsion. Bull. Fish. Res. Board Can., 190, 158 p.

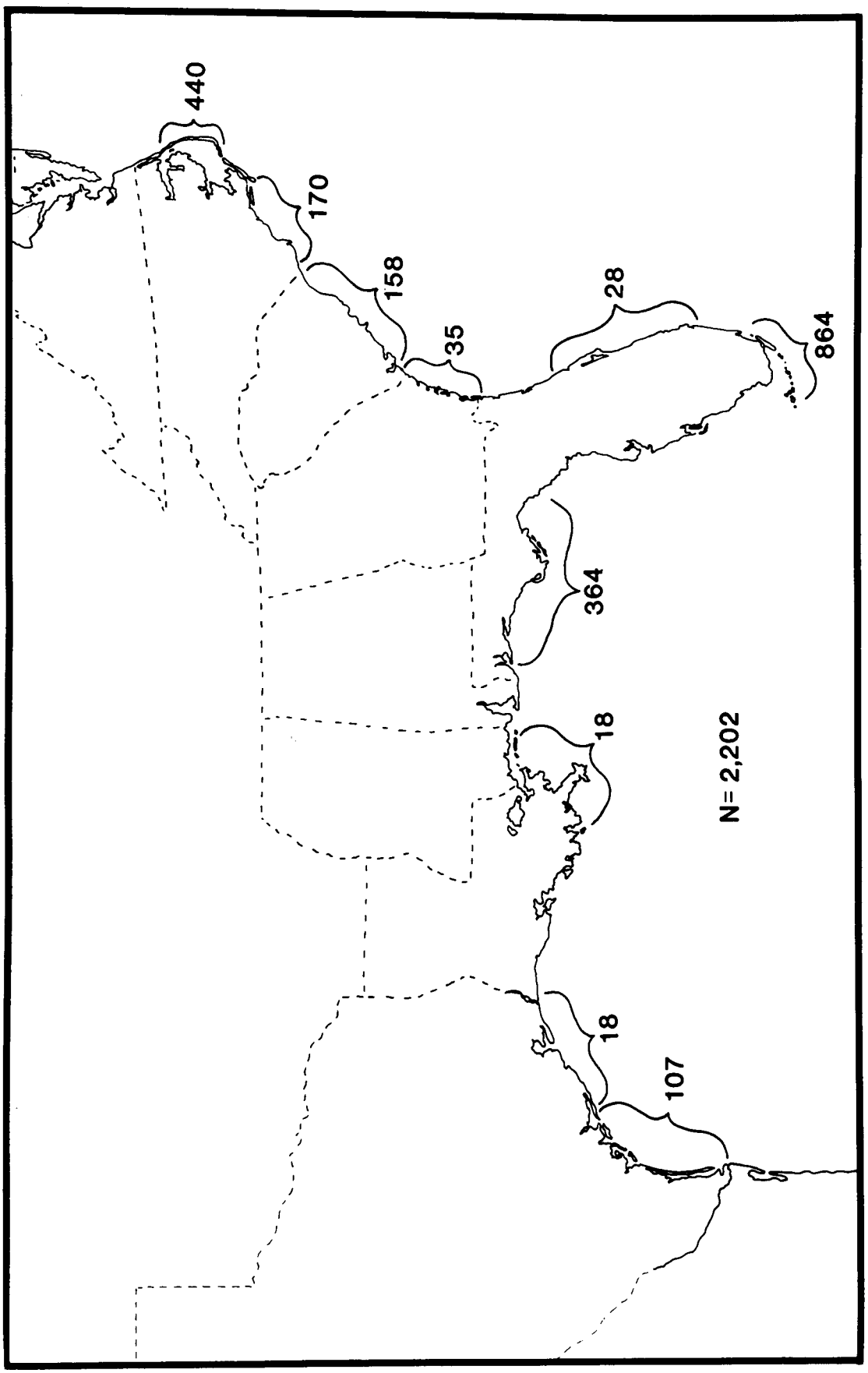

Figure 1. Sampling areas along the southeastern United States and in the Gulf of Mexico. The number at each location indicates dolphin, Coryphaena hippurus, with stomach contents.

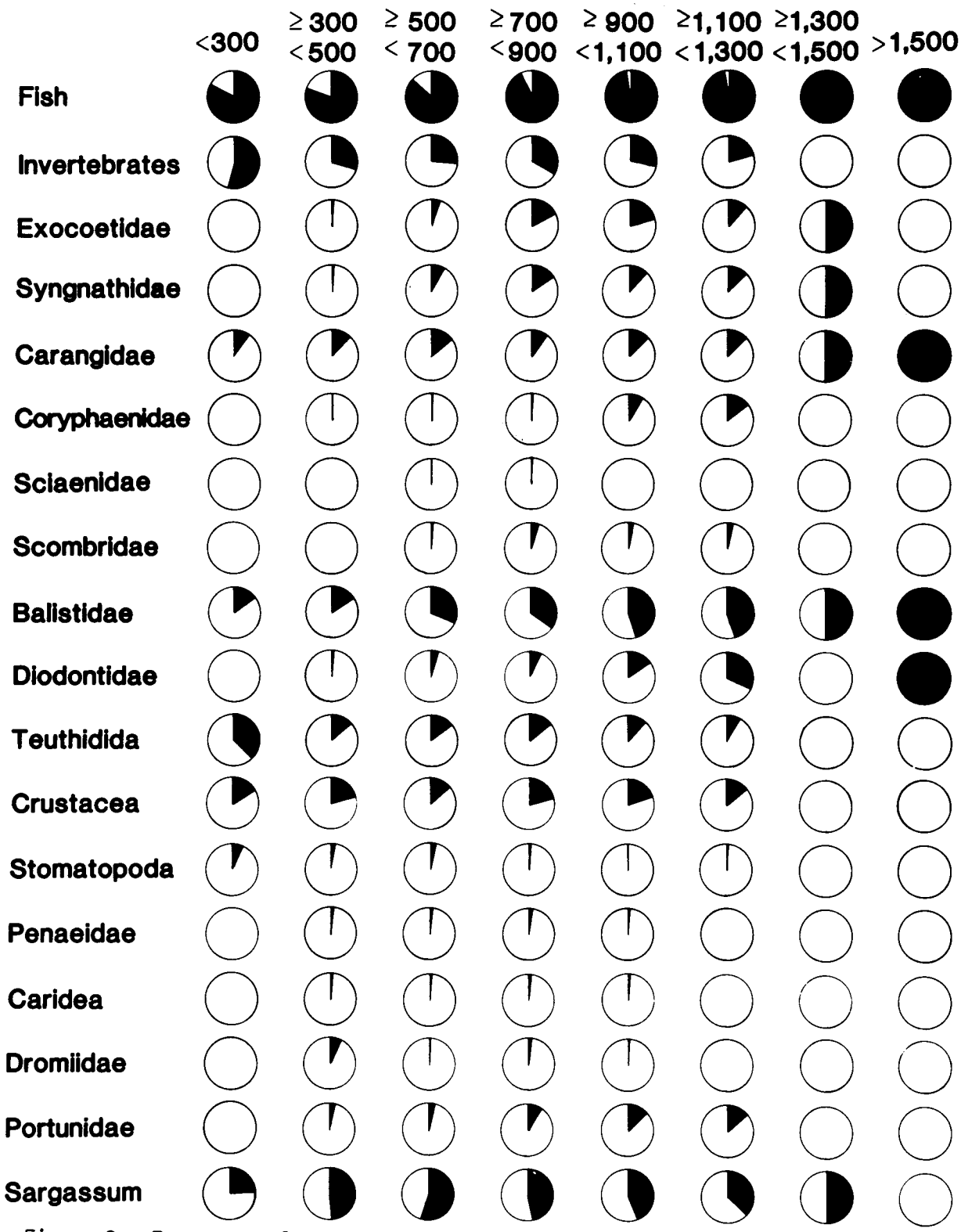

Figure 2. Frequency of occurrence percentages for selected foods identified in the stomachs of dolphin, Coryphaena hippurus, stratified by predator size (mm FL).

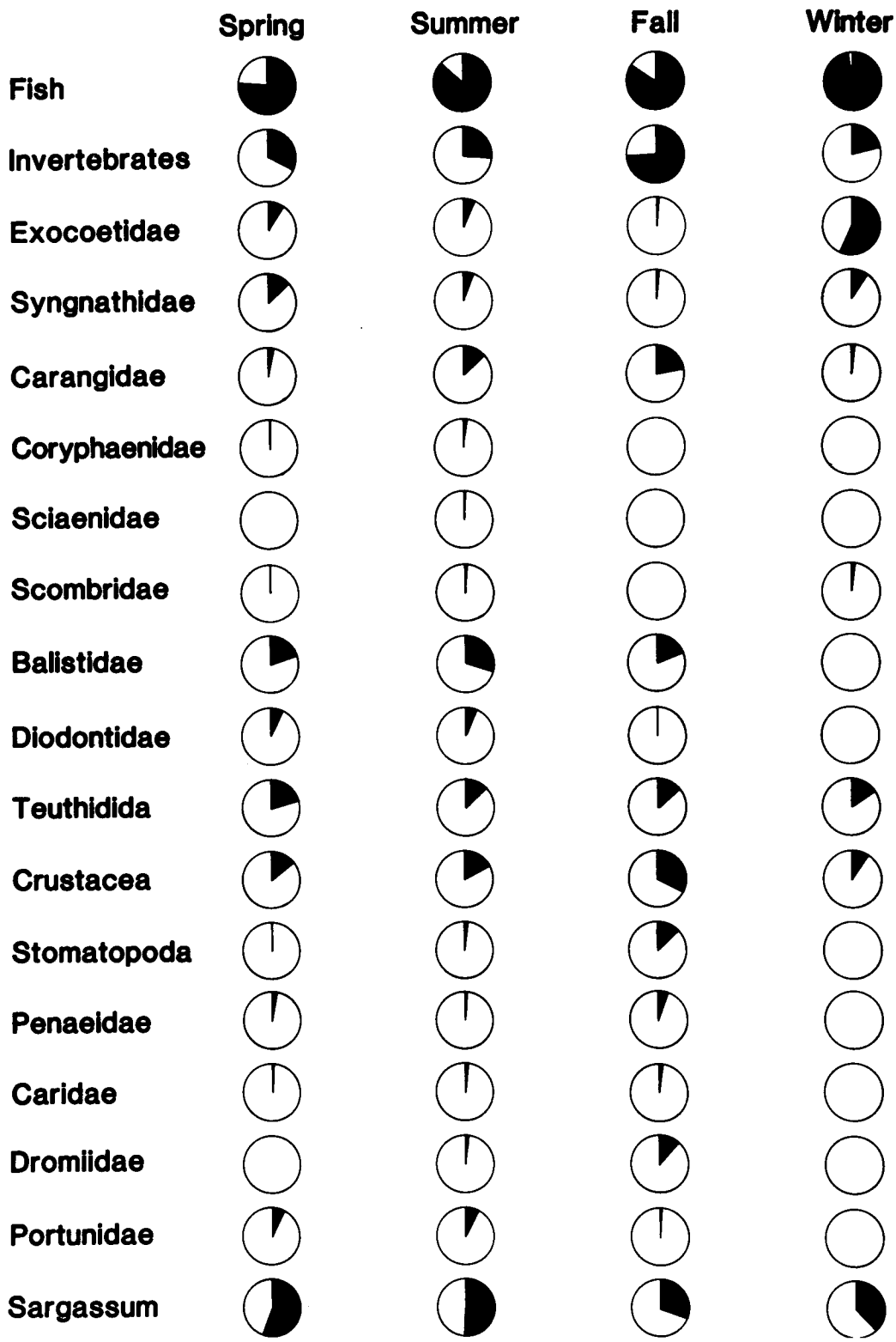

Figure 2. Frequency of occurrence percentages for selected foods identified in the stomachs of dolphin, Coryphaena hippurus, stratified by season of collection.

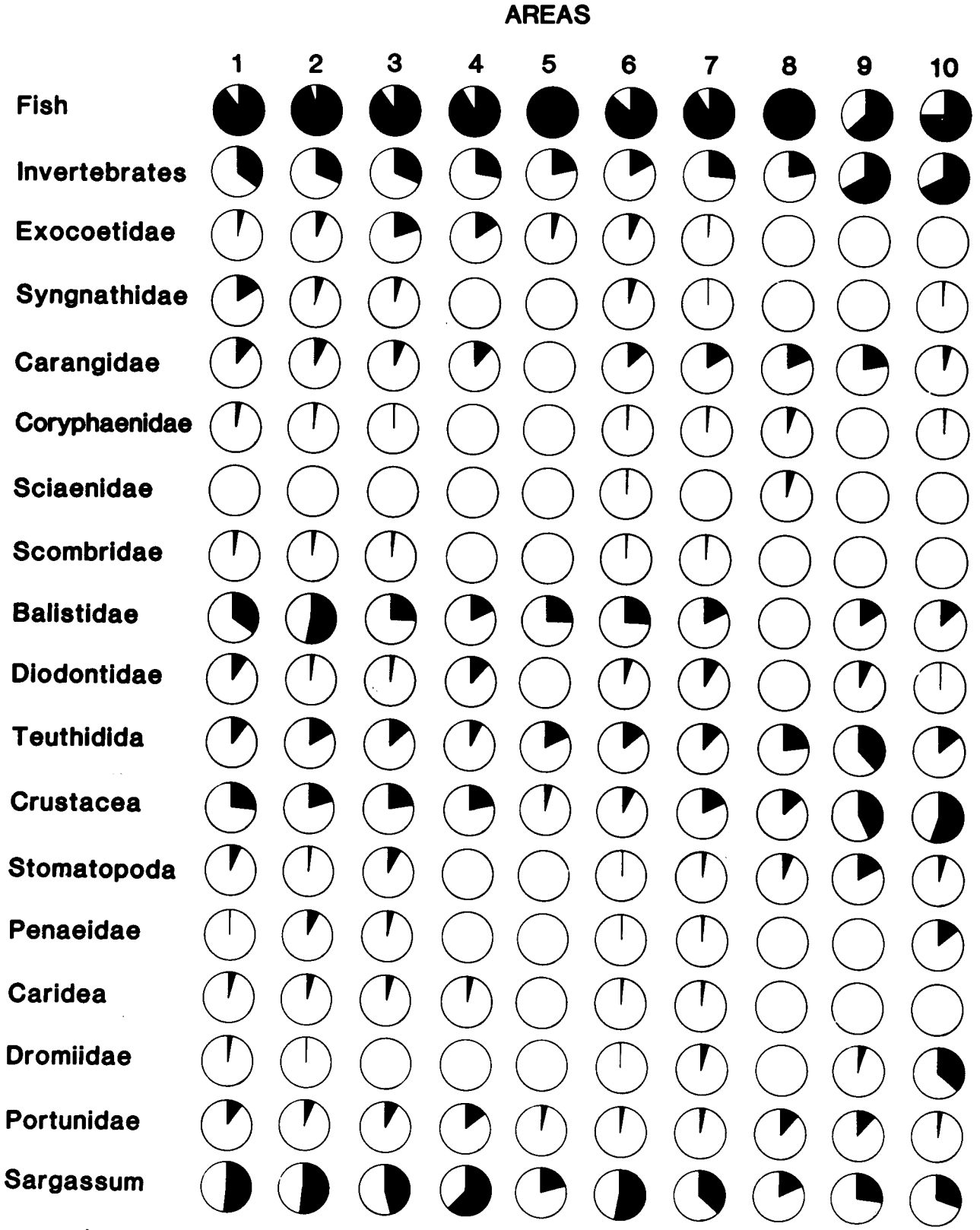

Figure 2. Frequency of occurrence percentages for selected foods identified in the stomachs of dolphin, Coryphaena hippurus, stratified by area of collection.

Table 1. Stomach contents of 2,219 dolphin collected off the southeastern United States and Gulf of Mexico in 1980 and 1981.

Item	IRI rank	Frequency of occurrence (N=2,219)	Percent frequency	Number of items (N=13,383)	Percent by number	Volume (N=57,648.2 ml)	Percent by volume
Fish		1,721	77.6	10,549	78.8	51,784.7	89.8
Unidentifiable fish	1	857	38.6	3,161	23.6	9.441.7	16.4
Unidentifiable juvenile fish		532	24.0	1,893	14.1	2,938.7	5.1
Family Clupeidae		25	1.1	107	0.8	363.5	0.6
Unidentifiable clupeid		20	0.9	92	0.7	235.0	0.4
Alosa sp.		1	TR	1	TR	10.0	TR
Etrumeus teres		2	0.1	2	TR	21.5	TR
Harengula jaguana		2	0.1	12	0.1	97.0	0.2
Family Engraulidae		6	0.3	26	0.2	47.5	0.1
Anchoa sp.		6	0.3	26	0.2	47.5	0.1
Family Synodontidae		1	TR	1	TR	15.0	TR
Synodus sp.		1	TR	1	TR	15.0	TR
Family Antennariidae		4	0.2	4	TR	76.0	0.1
Histrio histrio		4	0.2	4	TR	76.0	0.1
Family Gadidae		1	TR	14	0.1	0.6	TR
Urophycis chuss		1	TR	14	0.1	0.6	TR
Family Exocoetidae	5	139	6.3	190	1.4	7,773.8	13.5
Unidentifiable exocoetid		22	1.0	33	0.2	748.0	1.3
Unidentifiable flyingfish		89	4.0	120	0.9	5,272.0	9.1
Cypselurus melanurus		3	0.1	3	TR	373.0	0.6
Euleptorhamphus velox		2	0.1	2	TR	58.0	0.1
Hemiramphus brasiliensis		23	1.0	32	0.2	1,322.8	2.3
Family Belonidae		3	0.1	3	TR	36.0	0.1
Unidentifiable needlefish		3	0.1	3	TR	36.0	0.1
Family Holocentridae		2	0.1	4	TR	3.5	TR
Unidentifiable squirrelfish		2	0.1	4	TR	3.5	TR
Family Syngnathidae	7	120	5.4	954	7.1	1.258.0	2.2
Unidentifiable seahorse		2	0.1	3	TR	3.0	TR
Unidentifiable pipefish		5	0.2	5	TR	7.3	TR
Hippocampus sp.		112	5.0	892	6.7	1,222.5	2.1
H. erectus		3	0.1	54	0.4	25.2	TR
Family Serranidae		1	TR	1	TR	110.0	0.2
Centropristis ocyurus		1	TR	1	TR	110.0	0.2

Table 1 (cont)

Item	IRI rank	Frequency of occurrence (N=2,219)	Percent frequency	Number of items (N=13,383)	Percent by number	Volume (N=57,648.2 ml)	Percent by volume
Family Priacanthidae		4	0.2	16	0.1	5.0	TR
Unidentifiable bigeye		1	TR	7	TR	1.0	TR
Pristigenys alta		3	0.1	9	0.1	4.0	TR
Family Echeneidae		1	TR	1	TR	1.0	TR
Unidentifiable remora		1	TR	1	TR	1.0	TR
Family Carangidae	4	222	10.0	479	3.6	4,253.0	7.4
Unidentifiable carangid		179	8.1	315	2.3	2,952.1	5.1
Caranx sp.		5	0.2	7	TR	371.5	0.6
C. crysos		5	0.2	8	0.1	15.9	TR
C. hippos		2	0.1	3	TR	1.5	TR
Chloroscombrus chrysurus		6	0.3	25	0.2	21.8	TR
Decapterus punctatus		27	1.2	93	0.7	384.0	0.7
Hemicaranx amblyrhynchus		4	0.2	4	TR	93.0	0.2
Selar crumenophthalmus		3	0.1	3	TR	28.0	TR
Selene sp.		2	0.1	2	TR	0.4	TR
S. setapinnis		5	0.2	6	TR	7.9	TR
S. vomer		2	0.1	2	TR	1.6	TR
Seriola sp.		1	TR	1	TR	130.0	0.2
S. rivoliana		1	TR	2	TR	60.0	0.1
S. zonata		5	0.2	5	TR	71.4	0.1
Trachinotus carolinus		1	TR	1	TR	0.1	TR
Trachurus lathami		1	TR	1	TR	8.8	TR
Uraspis secunda		1	TR	1	TR	105.0	0.2
Family Coryphaenidae	8	36	1.6	47	0.3	12,891.0	22.4
Coryphaena hippurus		36	1.6	47	0.3	13,891.0	22.4
Family Lutjanidae		1	TR	1	TR	160.0	0.3
Lutjanus jocu		1	TR	1	TR	160.0	0.3
Family Lobotidae		6	0.3	6	TR	217.0	0.4
Lobotes surinamensis		6	0.3	6	TR	217.0	0.4
Family Sparidae		7	0.3	11	0.1	208.4	0.4
Unidentifiable porgy		1	TR	1	TR	0.1	TR
Lagodon rhomboides		5	0.2	9	0.1	208.2	0.4
Pagrus pagrus		1	TR	1	TR	0.1	TR
Family Sciaenidae		2	0.1	3	TR	87.8	0.1
Unidentifiable drum		1	TR	1	TR	18.0	TR
Cynoscion sp.		1	TR	2	TR	69.8	0.1
Family Pomacentridae		3	0.1	3	TR	20.0	TR
Unidentifiable damselfish		3	0.1	3	TR	20.0	TR

Table 1 (cont).

Item	IRI rank	Frequency of occurrence (N=2,219)	Percent frequency	Number of items (N=13,383)	Percent by number	Volume (N=57,648.2 ml)	Percent by volume
Family Mullidae		2	0.1	2	TR	0.8	TR
Mullus auratus		2	0.1	2	TR	0.8	TR
Family Kyphosidae		1	TR	1	TR	35.0	0.1
Kyphosus sectatrix		1	TR	1	TR	35.0	0.1
Family Chaetodontidae		2	0.1	2	TR	0.5	TR
Chaetodon sp.		2	0.1	2	TR	0.5	TR
Family Mugilidae		4	0.2	19	0.1	340.1	0.6
Mugil sp.		3	0.1	18	0.1	105.1	0.2
M. curema		1	TR	1	TR	235.0	0.4
Family Acanthuridae		3	0.1	3	TR	2.2	TR
Acanthurus sp.		2	0.1	2	TR	1.2	TR
A. coeruleus		1	TR	1	TR	1.0	TR
Family Trichiuridae		13	0.6	13	0.1	275.9	0.5
Trichiurus lepturus		13	0.6	13	0.1	275.9	0.5
Family Scombridae		25	1.1	72	0.5	1,402.3	2.4
Unidentifiable scombrid		18	0.8	22	0.2	1,208.0	2.1
Auxis thazard		1	TR	1	TR	170.0	0.3
Euthynnus alletteratus		2	0.1	9	0.1	4.0	TR
Scomber japonicus		4	0.2	40	0.3	20.3	TR
Family Istiophoridae		1	TR	1	TR	6.0	TR
Istiophorus platypterus		1	TR	1	TR	6.0	TR
Family Stomateidae		10	0.4	22	0.2	463.8	0.8
Hyperoglyphe perciformis		1	TR	1	TR	15.0	TR
Peprilus sp.		4	0.2	10	0.1	380.0	0.7
P. alepidotus		2	0.1	6	TR	11.6	TR
P. burti		3	0.1	5	TR	57.2	0.1
Family Dactylopteridae		6	0.3	6	TR	4.5	TR
Dactylopterus volitans		6	0.3	6	TR	4.5	TR
Family Bothidae		4	0.2	15	0.1	212.0	0.4
Unidentifiable flounder		4	0.2	15	0.1	212.0	0.4
Family Balistidae	2	698	31.5	3,150	23.5	7,601.9	13.2
Unidentifiable balistid		82	3.7	162	1.2	414.4	0.7
Unidentifiable filefish		154	6.9	500	3.7	946.9	1.6
Unidentifiable triggerfish		75	3.4	132	1.0	735.2	1.3
Aluterus sp.		94	4.2	170	1.3	1,323.7	2.3
A. schoepfi		1	0.1	1	TR	0.1	TR
A. scriptus		3	0.1	3	TR	33.0	0.1

Table 1 (cont).

Item	IRI rank	Frequency of occurrence (N=2,219)	Percent frequency	Number of items (N=13,383)	Percent by number	Volume (N=57,648.2 ml)	Percent by volume
Balistes capriscus		24	1.1	43	0.3	460.9	0.8
Cantherhines sp.		67	3.0	96	0.7	416.1	0.7
C. pullus		8	0.4	21	0.2	114.0	0.7
Canthidermis sufflamen		3	0.1	3	TR	9.3	TR
Melichthys niger		1	TR	1	TR	7.0	TR
Monacanthus sp.		201	9.1	1,949	14.6	2,946.5	5.1
M. hispidus		10	0.4	73	0.5	194.5	0.3
Family Ostraciidae		2	0.1	2	TR	0.8	TR
Unidentifiable boxfish		1	TR	1	TR	0.5	TR
Lactophrys triqueter		1	TR	1	TR	0.3	TR
Family Tetraodontidae		22	1.0	37	0.3	56.6	0.1
Unidentifiable puffer		19	0.8	36	0.3	56.1	0.1
Sphoeroides sp.		1	TR	1	0.1	0.5	TR
Family Diodontidae	10	116	5.2	279	2.1	1,474.8	2.6
Unidentifiable porcupinefish		62	2.8	131	1.0	485.3	0.8
Chilomycterus sp.		15	0.7	20	0.1	59.8	0.1
Diodon hystrix		41	1.8	128	1.0	929.7	1.6
Invertebrates		610	27.5	2,834	21.2	3,421.4	5.9
Phylum Porifera		1	TR	1	TR	2.5	TR
Unidentifiable siliceous sponge		1	TR	1	TR	2.5	TR
Phylum Cnidaria		1	TR	3	TR	4.0	TR
Porpita porpita		1	TR	3	TR	4.0	TR
Phylum Rhynchocoela		1	TR	1	TR	TR	TR
Unidentifiable nemertean		1	TR	1	TR	TR	TR
Phylum Mollusca		292	13.2	333	2.5	2,473.3	4.3
Unidentifiable molluscan		1	TR	1	TR	1.0	TR
Unidentifiable shell " hash "		1	TR	1	TR	1.0	TR
Class Gastropoda		2	0.1	2	TR	0.9	TR
Class Cephalopoda		286	12.9	329	2.5	2,470.4	4.3
Unidentifiable cephalopod		2	0.1	2	TR	0.6	TR
Order Teuthidida	6	281	12.7	316	2.4	2,392.2	4.1
Order Octopodida		9	0.4	11	0.1	77.6	0.1
Argonauta argo		9	0.4	11	0.1	77.6	0.1
Phylum Annelida		1	TR	1	TR	TR	TR
Class Polychaeta		1	TR	1	TR	TR	TR

Table 1 (cont).

Item	Frequency of occurrence (N=2,219)	Percent frequency	Number of items (N=13,383)	Percent by number	Volume (N=57,648.2 ml)	Percent by volume	IRI rank
Phylum Arthropoda	384	17.3	2,492	18.6	927.1	1.6	
Class Crustacea	374	16.8	2,481	18.5	924.2	1.6	3
Unidentifiable crustacean	15	0.7	13	0.1	17.5	TR	
Unidentifiable crustacean larvae	5	0.2	21	0.1	0.3	TR	
Order Stomatopoda	63	2.8	1,574	11.8	287.7	0.5	9
Unidentifiable stomatopod	2	0.1	2	TR	4.2	TR	
Unidentifiable stomatopod (larvae)	62	2.8	1,572	11.7	283.5	0.5	
Order Isopoda	7	0.3	26	0.2	4.0	TR	
Order Amphipoda	2	0.1	2	TR	0.7	TR	
Unidentifiable amphipod	1	TR	1	TR	0.7	TR	
Suborder Gammaridea	1	TR	1	TR	TR	TR	
Order Decapoda	311	14.0	845	6.3	614.0	1.1	
Unidentifiable decapod	4	0.2	6	TR	0.8	TR	
Unidentifiable decapod (zoeae)	2	0.1	4	TR	0.1	TR	
Unidentifiable decapod (larvae)	5	0.2	1	TR	TR	TR	
Suborder Natantia	119	5.4	195	1.5	225.4	0.4	
Unidentifiable shrimp	11	0.5	20	0.1	30.6	TR	
Unidentifiable shrimp (larvae)	5	0.2	28	0.2	1.0	TR	
Section Penaeidea	41	1.8	60	0.4	178.1	0.3	
Unidentifiable penaeid	6	0.3	6	TR	13.7	TR	
Cerataspis monstrosa (larvae)	2	0.1	2	TR	1.2	TR	
Penaeus sp.	11	0.5	13	0.1	62.3	0.1	
P. aztecus	1	TR	1	TR	7.0	TR	
P. duorarum	5	0.2	7	TR	26.0	TR	
Sicyonia sp.	9	0.4	12	0.1	39.4	0.1	
S. brevirostris	13	0.6	19	0.1	28.5	TR	
Section Caridea	49	2.2	87	0.6	15.7	TR	
Unidentifiable carid	18	0.8	20	0.1	2.5	TR	
Latreutes fucorum	10	0.4	18	0.1	0.7	TR	
Leander tenuicornis	22	1.0	49	0.4	12.5	TR	
Suborder Reptantia	229	10.3	639	4.7	387.7	0.7	
Unidentifiable crab	5	0.2	10	0.1	12.9	TR	
Unidentifiable reptantia (megalopa)	17	0.8	19	0.1	7.0	TR	
Section Anomura	3	0.1	5	TR	0.1	TR	
Subfamily Diogeninae (glaucothoe)	1	TR	1	TR	TR	TR	
Family Albuneidae	2	0.1	4	TR	0.1	TR	
Albunea sp. (larvae)	2	0.1	4	TR	0.1	TR	

Table 1 (cont).

Items	Frequency of occurrence (N=2,219)	Percent frequency	Number of items (N=13,383)	Percent by number	Volume (N=57,648.2 ml)	Percent by volume	IRI rank
Section Brachyurua	198	8.9	603	4.5	367.6	0.6	
Family Raninidae (megalopa)	7	0.3	17	0.1	2.2	TR	
Subsection Dromiacea (larvae)	6	0.3	13	0.1	1.2	TR	
Family Dromiidae (megalopa)	79	3.6	293	2.2	31.3	0.1	
Family Portunidae	114	5.1	280	2.1	333.0	0.6	
Unidentifiable portunid	37	1.7	8	0.1	3.1	TR	
Unidentifiable portunid (zoeae)	22	1.0	2	TR	1.2	TR	
Unidentifiable portunid (megalopa)	1	TR	54	0.4	0.1	TR	
Callinectes sapidus	1	TR	4	TR	16.0	TR	
Portunus sp.	60	2.7	130	1.0	136.9	0.2	
P. sayi	39	1.8	75	0.6	160.0	0.3	
P. spinicarpus	6	0.3	7	TR	15.7	TR	
Family Pinnotheridae	1	TR	1	TR	TR	TR	
Unidentifiable pinnotherid (juvenile)	1	TR	1	TR	TR	TR	
Class Insecta	10	0.4	11	0.1	2.9	TR	
Order Odonata	1	TR	1	TR	1.5	TR	
Unidentifiable dragonfly	1	TR	1	TR	1.5	TR	
Order Hemiptera	2	0.1	2	TR	0.8	TR	
Unidentifiable true bug	2	0.1	2	TR	0.8	TR	
Order Coleoptera	6	0.3	7	TR	0.5	TR	
Unidentifiable beetle	4	0.2	5	TR	0.3	TR	
Whirligig beetle	1	TR	1	TR	0.1	TR	
Potato beetle	1	TR	1	TR	0.1	TR	
Order Hymeoptera	1	TR	1	TR	0.1	TR	
Phylum Echinodermata	1	TR	1	TR	2.0	TR	
Class Echinoidea	1	TR	1	TR	2.0	TR	
Unidentifiable sand dollar	1	TR	1	TR	2.0	TR	
Subphylum Urochordata	2	0.1	2	TR	12.5	TR	
Class Ascidiacea	1	0.1	1	TR	12.5	TR	
Class Thaliacea	1	0.1	1	TR	TR	TR	
Class Salpida	1	0.1	1	TR	TR	TR	
Miscellaneous	1,123	50.6			2,442.1	4.2	
Unidentifiable contents	28	1.3			41.4	0.1	
Unidentifiable bird bone	2	0.1			0.6	TR	
Unidentifiable feather	1	TR			0.2	TR	
Unidentifiable plant material	8	0.4			4.9	TR	
Codium sp.	1	TR			0.2	TR	

Table 1 (cont).

Item	Frequency of occurrence (N=2,219)	Percent frequency	Number of items (N=13,383)	Percent by Number	Volume (N=57,648.2 ml)	Percent by Volume	IRI rank
Sargassum	1,079	48.6			1,839.9	3.2	
Thalassia testudinum	31	1.4			60.0	0.1	
Zostera marina	71	3.2			156.1	0.3	
Spartina patens	12	0.5			141.0	0.2	
Mangrove seed	1	TR			50.0	0.1	
Mangrove root	1	TR			5.0	TR	
Mangrove leaves	1	TR			1.0	TR	
Unidentifiable seed	2	0.1			1.1	TR	
Corn kernels (yellow)	1	TR			1.0	TR	
Nylon rope (white)	1	TR			6.0	TR	
Fish hook, small weight on long line	1	TR			3.5	TR	
Feather jig	1	TR			1.5	TR	
Tar ball	5	0.2			8.6	TR	
Light bulb	1	TR			0.4	TR	
Rocks	2	0.1			2.0	TR	
Black fibers	1	TR			TR	TR	
Black string	1	TR			1.0	TR	
Paper ribbon (kelly green)	1	TR			1.0	TR	
White paper (card board)	1	TR			15.0	TR	
Cellophane	3	0.1			8.5	TR	
Cigarette filter	1	TR			1.0	TR	
Plastic bottle, top half	1	TR			10.0	TR	
"Thermos" cooler jug, top half	1	TR			25.0	TR	
Orange-red plastic, German	1	TR			10.0	TR	
Blue plastic	1	TR			0.1	TR	
White plastic	4	0.2			6.3	TR	
Black plastic	3	0.1			11.0	TR	
Hot pink plastic	1	TR			0.1	TR	
Pink plastic	2	0.1			1.2	TR	
Brown plastic	1	TR			1.0	TR	
Orange plastic	1	TR			2.5	TR	

Table 2. Parasitism by nematodes (and trematodes) in dolphin, Coryphaena hippurus, stratified by fish size.

Dolphin Size (mm TL)	Fish	Fish w/Parasites	Percentage w/Parasites	Number of Parasites	Mean number/ fish w/Parasites	Mean Number/ All Fish
300	13	0(0)	0.00 (0.00)	0(0)	0.00 (0.00)	0.00 (0.00)
≥300 - < 500	1,199	8(3)	0.67 (0.25)	39(3)	4.875 (1.00)	0.03 (0.0025)
≥500 - < 700	832	25(7)	3.00 (0.84)	105(6)	4.20 (0.857)	0.13 (0.007)
≥700 - < 900	223	34(5)	15.25 (2.24)	399(7)	11.74 (1.40)	1.79 (0.031)
≥900 - <1,100	205	30(1)	14.63 (0.49)	473(1)	15.77 (1.00)	2.31 (0.005)
≥1,100 - <1,300	75	17(1)	22.67 (0.01)	249(1)	14.65 (1.00)	3.32 (0.01)
≥1,300 - <1,500	3	1(0)	33.33 (0.00)	1(0)	1.00 (0.00)	0.33 (0.00)
≥1,500	1	0(0)	0.00 (0.00)	0(0)	0.00 (0.00)	0.00 (0.00)
Totals	2,551	117(17)	4.51 (0.67)	1,266(18)	11.01 (1.06)	

Table 3. Parasitism by nematodes (and trematodes) in dolphin, Coryphaena hippurus, stratified by season of collection.

Season	Fish	Fish w/Parasites	Percentages w/Parasites	Number of Parasites	Mean number w/Parasites	Mean number all fish
Winter	40	2 (3)	5.00 (7.50)	104 (2)	52.00 (0.67)	2.6 (0.05)
Spring	377	24 (6)	6.37 (1.59)	338 (6)	14.10 (1.00)	0.9 (0.003)
Summer	1,951	88 (6)	4.51 (0.30)	827 (8)	9.40 (1.33)	0.42 (0.004)
Fall	244	3 (2)	1.23 (0.82)	5 (2)	1.70 (1.00)	0.02 (0.008)
Totals	2,612	117 (17)	4.47 (0.65)	1.274 (18)		

Table 4. Parasitism by nematodes (and trematodes) in dolphin, Coryphaena hippurus, stratified by area of collection.

Area	Fish	Fish w/Parasites	Percentages w/Parasites	Number of Parasites	Mean number of fish w/Parasites	Mean Number all fish
Cape Hatteras	494	58 (2)	11.74 (0.40)	594 (2)	10.24 (1.00)	1.20 (0.004)
Cape Lookout	184	9 (7)	4.89 (3.80)	110 (26)	12.22 (3.71)	0.60 (0.14)
South Carolina	168	13 (0)	7.74 (0.00)	240 (0)	18.46 (0.00)	1.43 (0.00)
Georgia	41	6 (0)	14.63 (0.00)	44 (0)	7.33 (0.00)	1.07 (0.00)
East Central Florida	44	0 (0)	0.00 (0.00)	0 (0)	0.00 (0.00)	0.00 (0.00)
South Florida	1,110	27 (9)	2.43 (0.81)	300 (9)	11.11 (1.00)	0.27 (0.008)
Northwest Florida	421	9 (1)	2.14 (0.24)	70 (1)	7.78 (1.00)	0.17 (0.002)
Mississippi Delta	21	3 (0)	14.29 (0.00)	73 (0)	24.33 (0.00)	3.48 (0.00)
Northeast Texas	25	1 (0)	4.00 (0.00)	1 (0)	1.00 (0.00)	0.04 (0.00)
South Texas	122	6 (0)	4.92 (0.00)	7 (0)	1.17 (0.00)	0.06 (0.00)
Totals	2,630	132 (19)	5.02 (0.72)	1,439 (38)		